



Environmental Effects of Dredging Technical Notes



CONSTRUCTION OF A SUBMERGED GRAVEL BAR HABITAT USING DREDGED MATERIAL

PURPOSE: This note provides information on techniques, materials, and equipment necessary to construct submerged aquatic habitats in large waterways using coarse-grained sediments.

BACKGROUND: Gravel bars are notable natural features of rivers and streams that have not been altered by water resource development. Gravel and cobble-sized materials provide points of attachment and anchorage for aquatic organisms such as insect larvae, snails, and worms (Hynes 1970). Coarse-grained particulates stabilize fine substrate and allow colonization by long-lived invertebrates such as freshwater mussels. Particle size distribution, degree of embeddedness, and presence of attached organic matter and plants determine the characteristics of invertebrate communities in flowing water systems (Cummins and Lauff 1968, Brusven and Prather 1974, Walton 1978).

Selected reaches of navigable waterways frequently have to be dredged to provide channel depths necessary for navigation. Environmental legislation such as the Rivers and Harbors Act of 1899 and the Endangered Species Act, as amended (1978), has encouraged beneficial uses of dredged silts and sands to create terrestrial or wetland habitat (Harrison and Luik 1980; Perrier, Llopis, and Spaine 1980; Newling and Landin 1985). However, gravel or other large-sized particles from dredging or other sources can be placed in flowing water to create shoals or bars. Gravel has been used to make trout habitat (Stuart 1953), to accelerate biological recovery in streams modified by channel development (Shields 1983), and to increase water velocity and provide substrate for invertebrates (King and Miller 1986). Habitat creation techniques in large waterways are fairly simple, operationally feasible, and should be considered when appropriate material and a suitable site are available. When incorporated into early planning, habitat development provides a mechanism to satisfy environmental concerns and still meet project purposes.

ADDITIONAL INFORMATION: Contact the author, Dr. Andrew C. Miller, (601)634-2141; or the EEDP Program Manager, Dr. Robert M. Engler, (601)634-3624.

19950328 068

Development of the Project

History

In the fall of 1983 a grain company accidentally dredged part of a mussel bed in the Ohio River near Mound City, Ill. The dredging took place during low water and was done to provide access to a loading facility. The mussel bed supports a diverse assemblage of species, including the orange-footed pimpleback, *Plethobasus cooperianus*, listed as endangered by the US Department of the Interior (1986). The grain company agreed to construct a gravel bar to compensate for damage. The bar had to be located outside the navigation channel in an area where physical conditions were suitable and there were no live mussels. Freshwater mussels require flowing water (<0.5 m/sec) and firm, stable substrate that is not susceptible to excessive sedimentation. A design for the habitat was prepared and, in August 1986, construction was initiated in the river.

Site selection

On the Kentucky side of the Ohio River across from Mound City, river miles (RM) 971.3-973.3, is an exposed shoal built with material from maintenance dredging (Figures 1 and 2). A submerged dike at the downstream end of the shoal helps to deflect water into the main channel. At normal pool elevation, water depth on the landward side of the shoal ranges from 3 to 4 m. The main component of the benthic fauna at this site is the Asiatic clam, *Corbicula fluminea* Muller, an introduced species (0-646/sq m, average = 224, standard deviation = 232.6, number = 9). Specimens were medium sized, with total shell length of 2 to 3 cm. Intensive searches in 1984 using a brail (a bar with 200 or more multipronged hooks that is dragged over the river bottom to capture live mussels) and scuba divers yielded only three live mussels. Live specimens in the area included: one ebonyshell (*Fusconaia ebena* Lea) and two pink heelsplitters (*Potamilus alatus* Say). Although substrate that supports mussels usually consists of sand and gravel (Figure 3A), the shoal consisted mainly of coarse sand with less than 10 percent gravel (Figure 3B).

A site with appropriate depth and water velocity was selected at RM 972.0. Water velocity at the bottom ranged from 20 to 33 cm/sec during low water, which is sufficient to remove previously settled silts but not erode larger particles (Vanoni 1975). Presence of Asiatic clams and a few larger

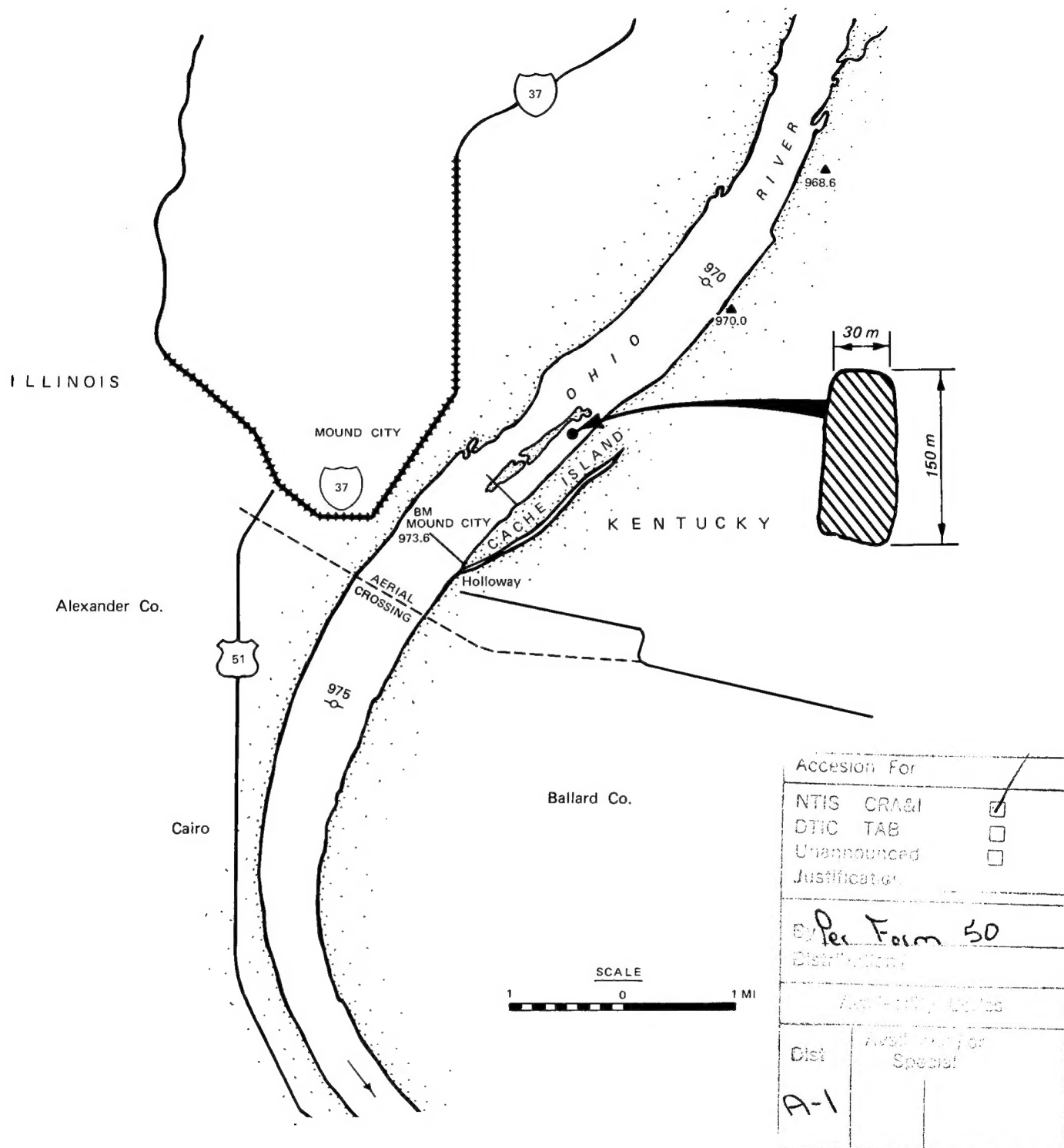


Figure 1. Gravel bar placed behind a shoal on the Kentucky side of the Ohio River near Mound City, Ill.

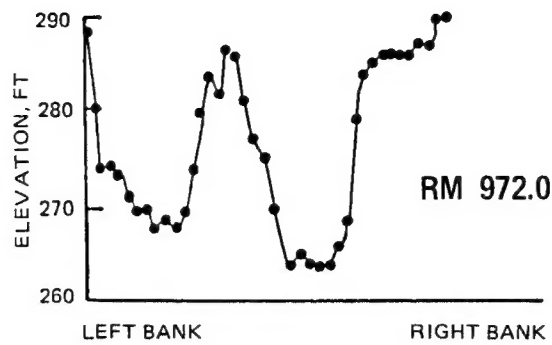


Figure 2. Depth profile at gravel bar construction site

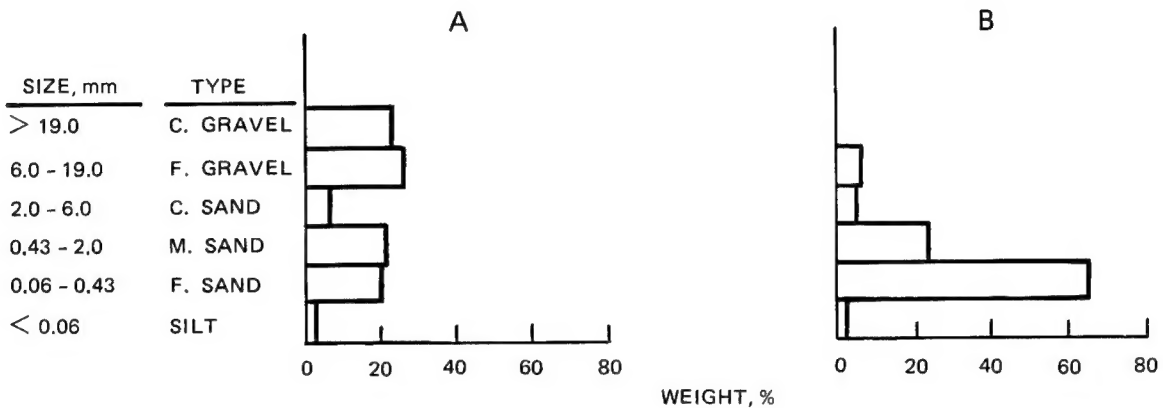


Figure 3. Particle-size distribution of inorganic sediments at a natural gravel bar (A) that supports freshwater mussels, and from the construction site (B)

mussels indicated that high current velocities do not disrupt the substrate. In addition, this site is outside the navigation channel and is protected from commercial traffic by the shoal and dikes.

Construction Details

Obtaining material

Gravel for the habitat (Figure 4) was pumped from the main channel using a hydraulic dredge with a 27.5-cm-diam intake pipe. Since substrate in the main channel consisted of a mixture of sand and gravel, all material was sieved through a 9.5-mm-diam screen. Only coarse sediments were retained for the habitat. Since sand was the predominant sediment type at the proposed site, only gravel was used to construct the new habitat. It took about 8 hr to pump and load 2,500 tons of material.

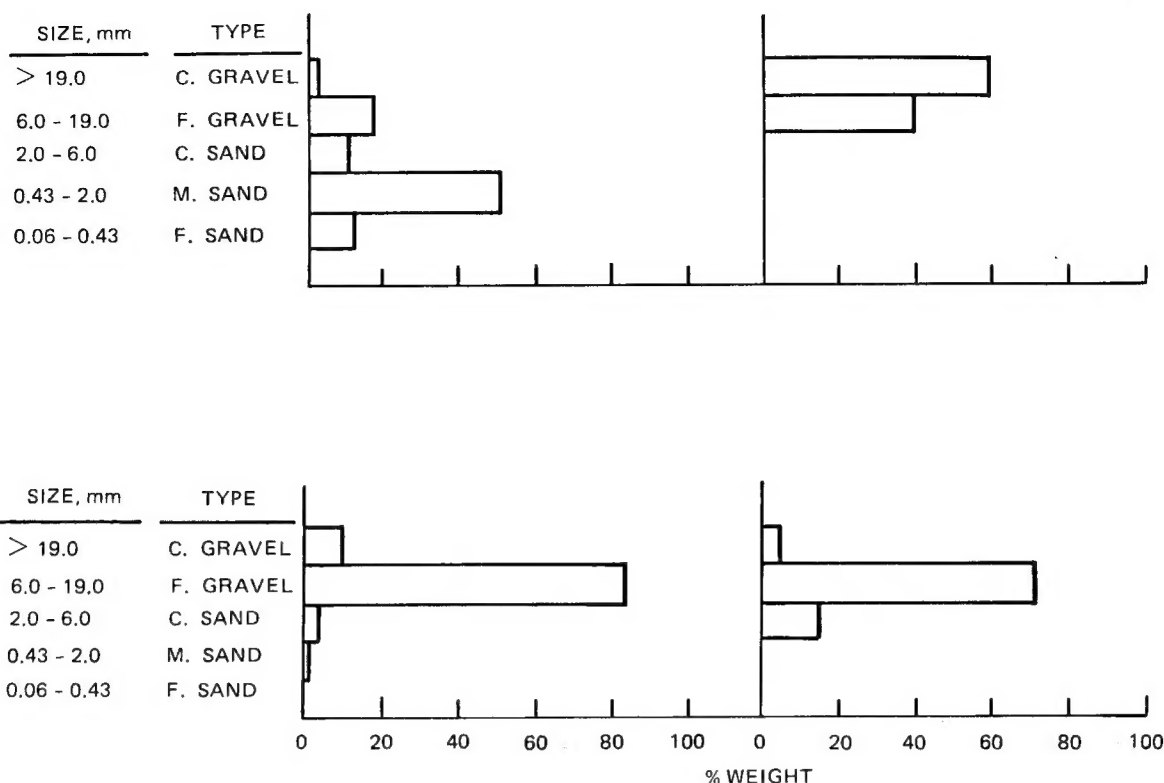


Figure 4. Particle-size distributions of materials used to construct the habitat, illustrating the range of sediment types used

Placing the gravel

The site was delineated by buoys that were set at 46-m intervals along the landward side of the habitat (Figure 5). A tug, crane, and materials (gravel) barge were positioned directly over the outside portion of the habitat. The crane operator used a 24-m boom and a 3.0-cu m clamshell bucket. About two-thirds of a bargeload of gravel was spread along the right side and front of the barge. The tug operator kept the barges in position throughout the operation; no anchors or "spuds" were used. The gravel was placed as evenly as possible by opening the bucket slowly as the boom moved above the water surface. After the majority of the gravel was placed along the front and right side of the barge, the equipment was moved approximately 15 m to the left. The remaining gravel was then placed where the barge was positioned when the first two-thirds of the gravel was spread.

Each 46-m section of the bar required one bargeload of gravel (about 800 cu m). Work proceeded downriver so that propeller wash from the tug would not disturb the newly placed gravel. It took from 4 to 6 hr to position the tug and equipment and unload a single barge. Four bargeloads of gravel, about

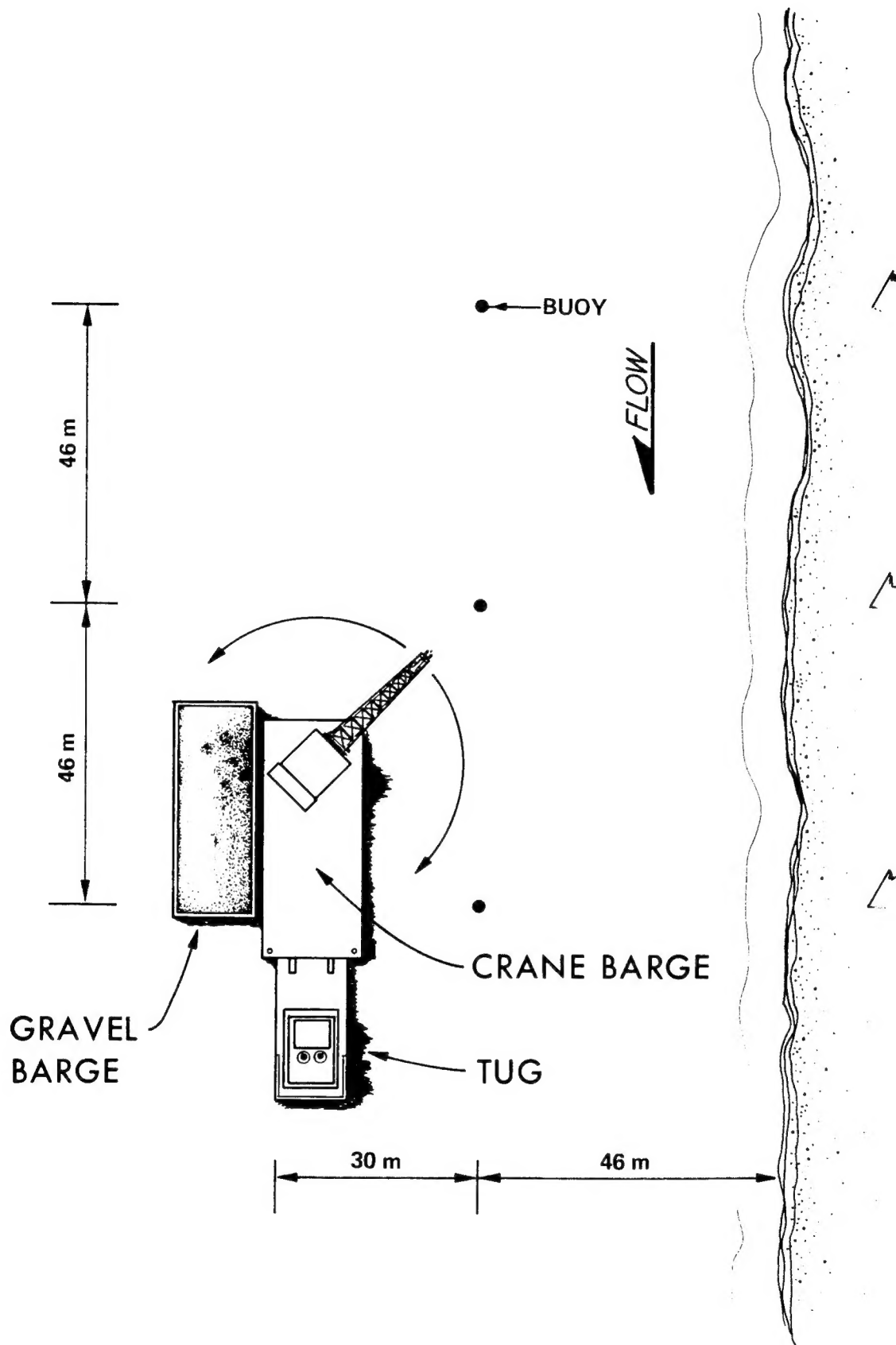


Figure 5. Placement of gravel in the river with a clamshell dredge

3,200 cu m of material, were placed on the river bottom during the 3-day construction period.

Evaluation of the Habitat

Postconstruction conditions

After all gravel had been spread, divers measured the actual dimensions of the bar, secured a reference cable down the center of the habitat (Figure 6), and collected substrate samples with a hand-held corer. The bar was 3 to 75 cm thick and was located within the area marked by the buoys. Each 5-cm increment of substrate contained approximately the same size distribution of particles (Figure 7). An even vertical distribution of dredged material was achieved by having the crane operator open the clamshell bucket slowly and spread the material layers. It was not necessary to smooth the gravel after it had been placed.

Continuing studies

Physical and biological conditions at the habitat have been and will continue to be measured for 4 years after placement (through fiscal year 1990). As part of this work, approximately 100 ebonyshell mussels (*Fusconaia ebena*) were collected from the Illinois side of the river. All specimens were marked and their total length and weight measured and placed either free in the substrate or in wire baskets attached to the cable. The marked mussels will be sampled on an annual basis to determine individual mortality and growth rates. Accumulation of fine inorganic and organic sediments will be measured using sediment traps constructed from 10-cm polyvinyl chloride pipe. The traps were filled with washed gravel (>1.27 cm) and placed just beneath the surface of the bar. The traps will be retrieved after 1 year and the substrate will be analyzed for accumulation of organic and fine inorganic material.

After the habitat has been in place for 1 year, sediment samples will be collected for grain-size analyses and for evaluation of macroinvertebrate density and community composition. Biological and physical characteristics of the new habitat will be compared to conditions at the natural gravel bar on the other side of the river.

Conclusions and Implications

Coarse gravel can be placed on sand substrate at suitable sites in large rivers to provide colonization sites for aquatic organisms. Permanent

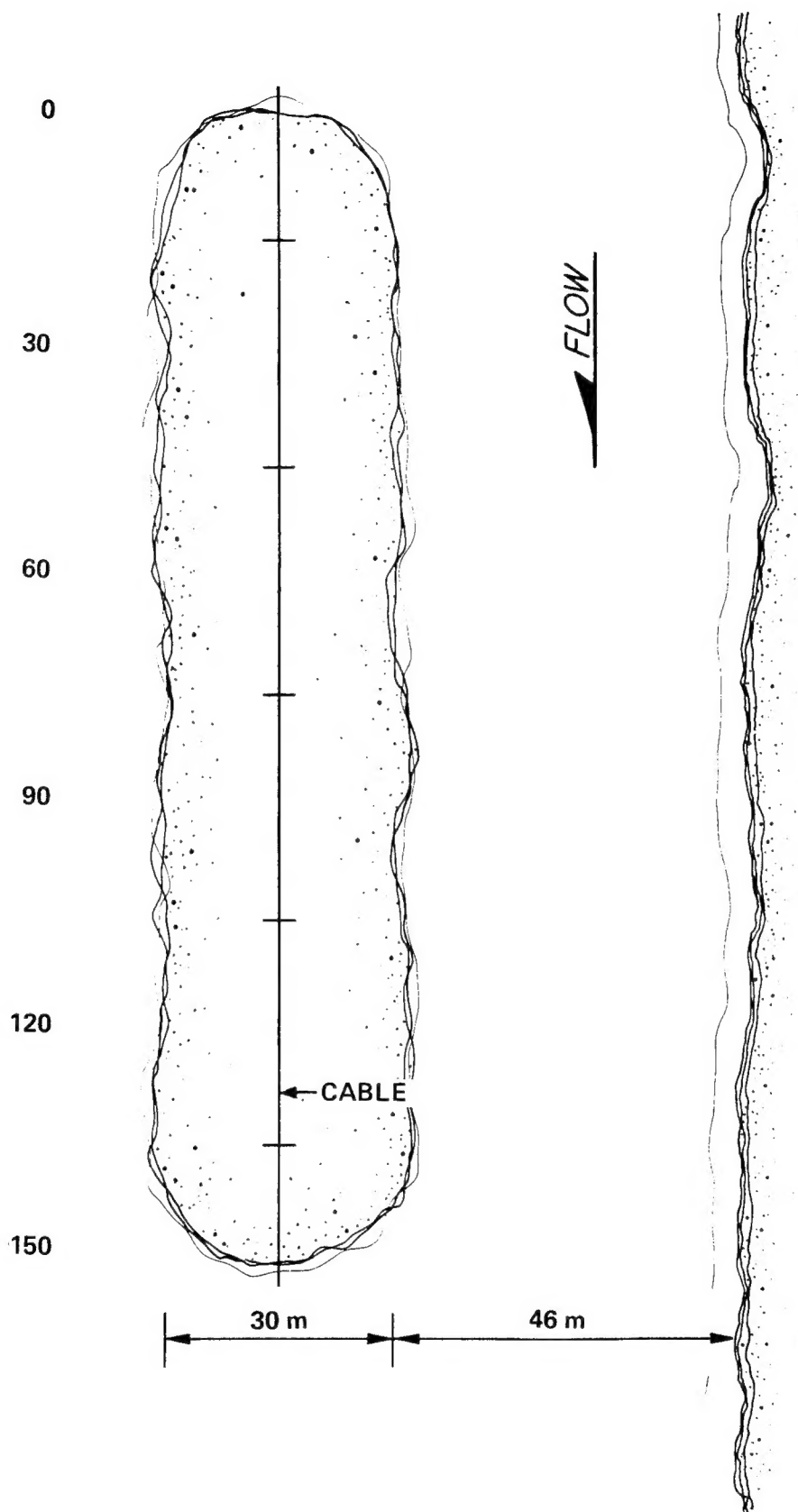


Figure 6. Completed gravel bar with reference cable to mark future study sites

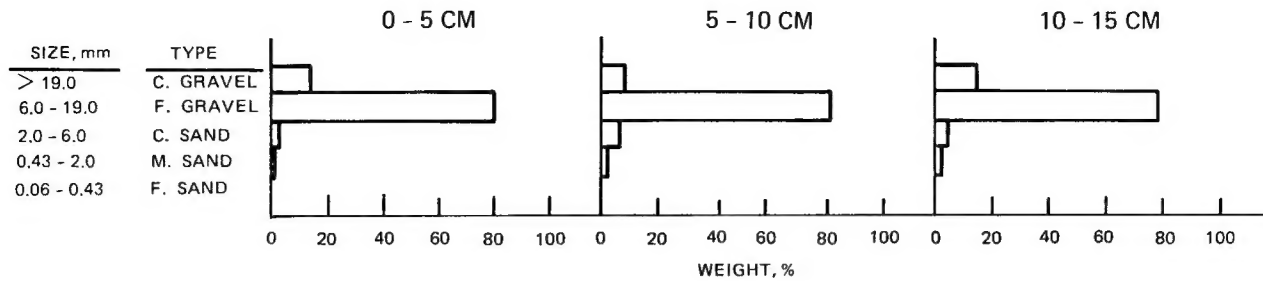


Figure 7. Vertical distribution of inorganic particles at the newly completed gravel bar, September 1986

habitats with a variety of substrate particle sizes, ample food supply, and suitable current velocity are necessary to develop a diverse and dense community of aquatic organisms. Gravel bars placed in carefully selected sites are capable of providing such habitat. They can be constructed in less than a week and, depending upon quantities of material required, for less than \$20,000. These habitats can be considered to offset potential adverse effects of maintenance dredging or as water resource development projects. In addition, they provide an opportunity to evaluate short- and long-term effects of habitat construction using coarse-grained sediments.

References

- Brusven, M., and Prather, K. 1974. "Influence of Stream Sediments on Distribution of Macroinvertebrates," *Journal of Entomology Society of British Columbia*, Vol 71, pp 25-32.
- Cummins, K., and Lauff, G. 1968. "The Influence of Substrate Particle Size on the Microdistribution of Stream Macroinvertebrates," *Hydrobiologia*, Vol 32, pp 145-181.
- Harrison, W., and Luik, A. 1980. "Suitability of Dredged Material for Reclamation of Surface-mined Land, Ottawa, Illinois, Demonstration Project," Technical Report EL-80-7, US Army Engineer Waterways Experiment Station, Vicksburg, Miss. (NTIS No. AD A088 586).
- Hynes, H. B. N. 1970. *The Ecology of Running Water*, University of Toronto Press, Toronto.
- King, R., and Miller, A. 1986. "Biological and Physicochemical Characteristics of Artificial Sections in an Abandoned Channel of the Tombigbee River," *Proceedings of the Third Water Quality and Wetlands Management Conference: Lakes, Rivers, and Streams*, New Orleans, La., pp 95-116.
- Newling, C., and Landin, M. 1985. "Long-Term Monitoring of Habitat Development at Upland and Wetland Dredged Material Disposal Sites, 1974-1982," Technical Report D-85-5, US Army Engineer Waterways Experiment Station, Vicksburg, Miss. (NTIS No. AD A159 106).
- Perrier, E., Llopis, J., and Spaine, P. 1980. "Area Strip Mine Reclamation Using Dredged Material: A Field Demonstration," Technical Report EL-80-4, US Army Engineer Waterways Experiment Station, Vicksburg, Miss. (NTIS No. AD A088 612).

Shields, F. 1983. "Design of Habitat Structures for Open Channels," *Journal of Water Resources Planning Management*, Vol 109, pp 331-344.

Stuart, T. A. 1953. "Water Currents Through Permeable Gravels and Their Significance to Spawning Salmoides," *Nature*, Vol 172, p 407.

US Department of the Interior. 1986. "Endangered and Threatened Wildlife and Plants," reprinted from the *Federal Register*, 50 CFR 17.11 and 17.12.

Vanoni, V. 1975. "Sediment Transport Mechanics," *Sedimentation Engineering*, ASCE Manuals on Engineering Practice No. 54, pp 91-107.

Walton, E. 1978. "Substrate Attachment by Drifting Aquatic Insect Larvae," *Ecology*, Vol 59, pp 1023-1030.